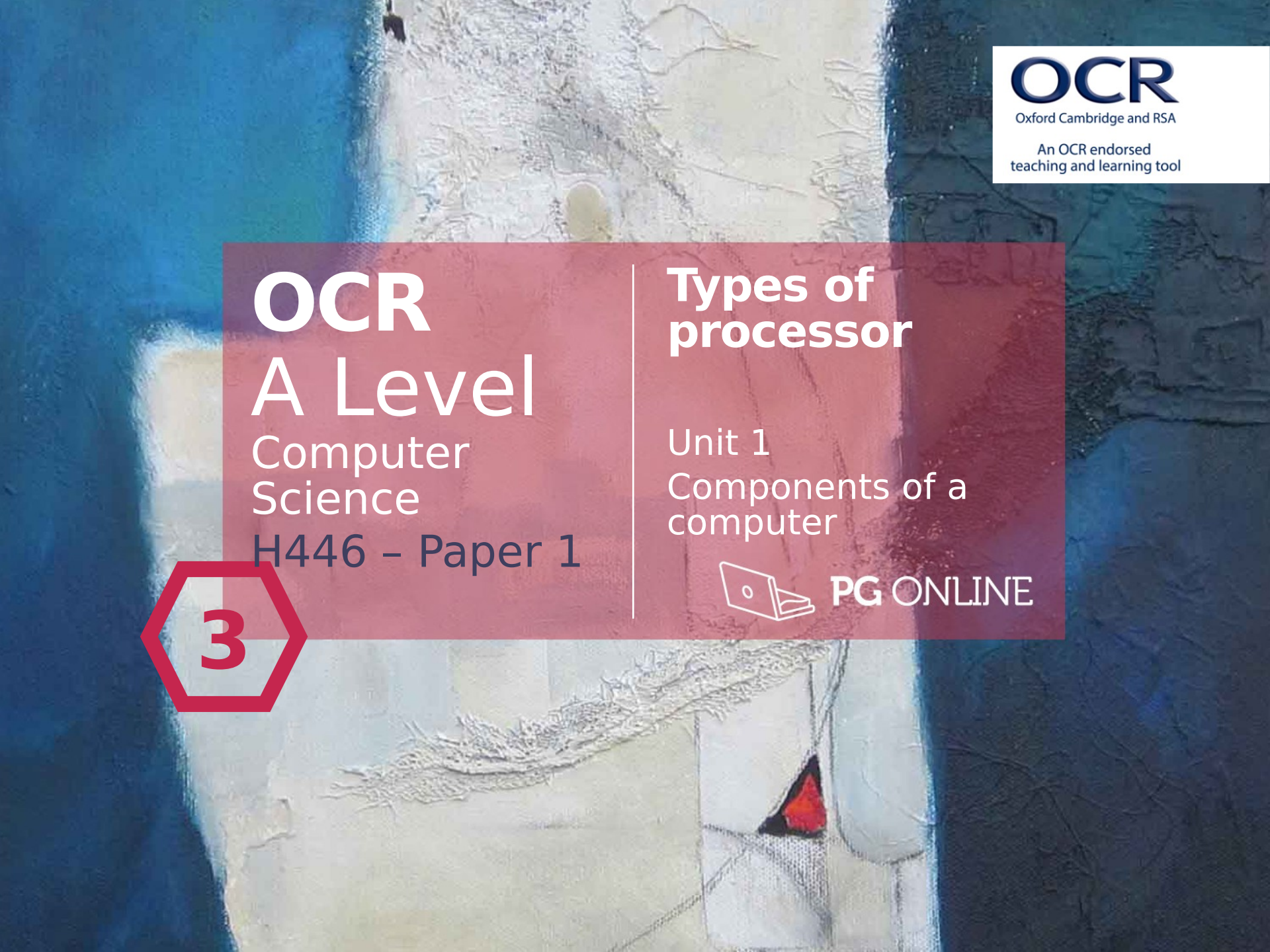

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3

Types of processor

Unit 1
Components of a computer

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Objectives

- Describe von Neumann, Harvard and contemporary processor architecture
- Describe the differences between, and uses of, CISC and RISC processors
- Describe GPUs and their uses
- Describe multicore and parallel systems

Multipurpose machines

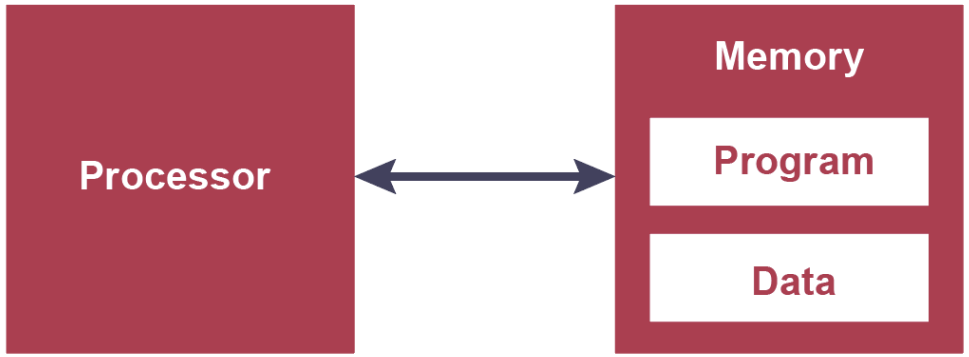
- Early computers were able to calculate an output using fixed instructions
  - They could perform only one set of instructions
- In the 1940s, John von Neumann and Alan Turing both proposed the stored program concept

Stored program concept

- A program must be loaded into main memory to be executed by the processor
- The instructions are fetched one at a time, decoded and executed sequentially by the processor
- The sequence of instructions can only be changed by a conditional or unconditional jump instruction

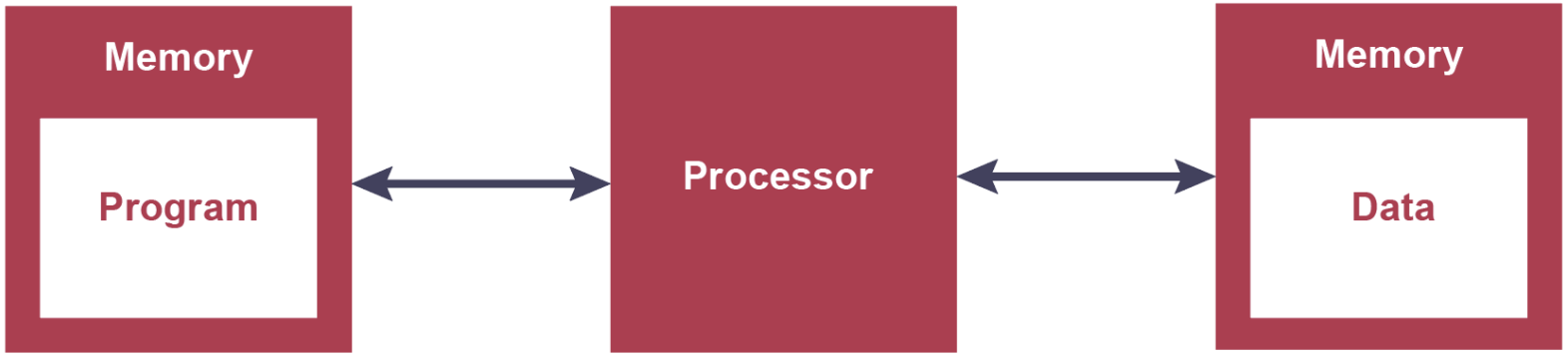
John von Neumann

- The most common implementation of this concept is the **von Neumann** architecture
- Instructions and data are stored in a common main memory and transferred using a single shared bus
  - What compromises might there be with a shared bus?



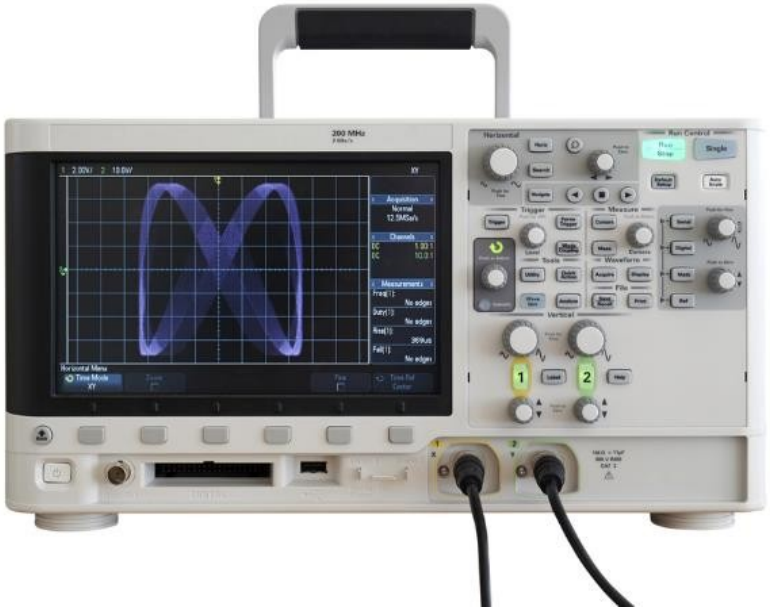
Harvard architecture

- An alternative model separates the data and instructions into separate memories using different buses
- Program instructions and data are no longer competing for the same bus



Use of Harvard architecture

- Different sized memories and word lengths can be used for data and instructions
- Harvard principles are used with specialist embedded systems and digital signal processing (DSP), where speed takes priority over the



Advantages of von Neumann architecture

- Owing primarily to cost and programming complexity, almost all general purpose computers are based on von Neumann's principles
- It simplifies the design of the Control Unit
- Data from memory and from devices are accessed in the same way

Von Neumann vs Harvard

- Fill in the blanks:

Von Neumann architecture	Harvard architecture
Used in PCs, laptops, servers and high performance computers	
Data and instructions share the same memory. Both use the same word length	
One bus for data and instructions is a bottleneck	
Control unit for two buses is more complicated and expensive	

Von Neumann vs Harvard

- Fill in the blanks:

Von Neumann architecture	Harvard architecture
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One bus for data and instructions is a bottleneck	Separate buses allow parallel access to data and instructions
Control unit for two buses is more complicated and expensive	

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One bus for data and instructions is a bottleneck	Separate buses allow parallel access to data and instructions
Control unit for two buses is more complicated and expensive	One bus is simpler for control unit design

Contemporary processor architectures

- Modern CPU chips often incorporate aspects of both von Neumann and Harvard architecture
- In desktop computers, there is one main memory for holding both data and instructions, but cache memory is divided into an instruction cache and a data cache so data and instructions are retrieved using Harvard architecture
    - Some digital signal processors have multiple parallel data buses (two write, three read) and one instruction bus

CISC and RISC

- In Complex Instruction Set Computers (CISC), a large instruction set is used to accomplish tasks in as few lines of assembly language as possible
  - A CISC instruction combines a “load/store” instruction with the instruction that carries out the actual calculation
- A single assembly language instruction such as

```
MULT A, B
```

could be used to multiply A by B and store the result back in A

RISC

- Reduced Instruction Set Computers (RISC) take an opposite approach
- A minimum number of very simple instructions, each taking one clock cycle, are used to accomplish all the required operations in multiple general purpose registers
  - How would the multiplication operation be carried out with the following operations?

```
LDA (LOAD)
STO (STORE)
MULT (MULTIPLY)
```

Coding in RISC

- The CISC instruction:

```
MULT A, B
```

Might be written in a RISC assembly code as:

```
LDA R1, A
LDA R2, B
MULT R1, R2
STO R1 A
```

Advantages of CISC and RISC

CISC	RISC
Quicker to code programs	The hardware is simpler to build with fewer circuits needed for carrying out complex instructions
The compiler has very little work to do to translate a high-level language statement into machine code	Because each instruction takes the same amount of time, i.e. one clock cycle, pipelining is possible
Because the code is relatively short, very little RAM is required to store the instructions	RAM is now cheap, and RISC use of RAM and software allows better performance processors at less cost

Worksheet slide

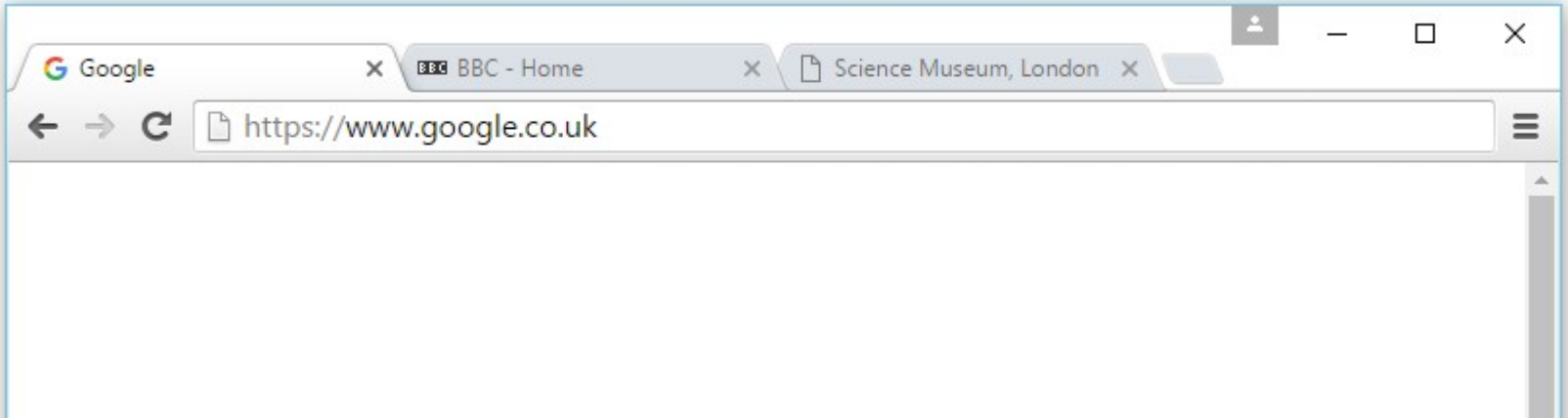
- Complete the questions in **Task 1** on **Worksheet 3**

Multi-core and parallel systems

- Multi-core processors are able to distribute workload across multiple processor cores, thus achieving significantly higher performance by performing several tasks in parallel
- They are therefore known as parallel systems
- Many personal computers and mobile devices are dual-core or quad-core, meaning they have two or four processing chips
- Supercomputers have thousands of cores

Using parallel processing

- The software has to be written to take advantage of multiple cores
- For example, browsers such as Google Chrome and Mozilla Firefox can run several concurrent processes
  - Using tabbed browsing, different cores can work simultaneously processing requests, showing videos



Co-processor systems

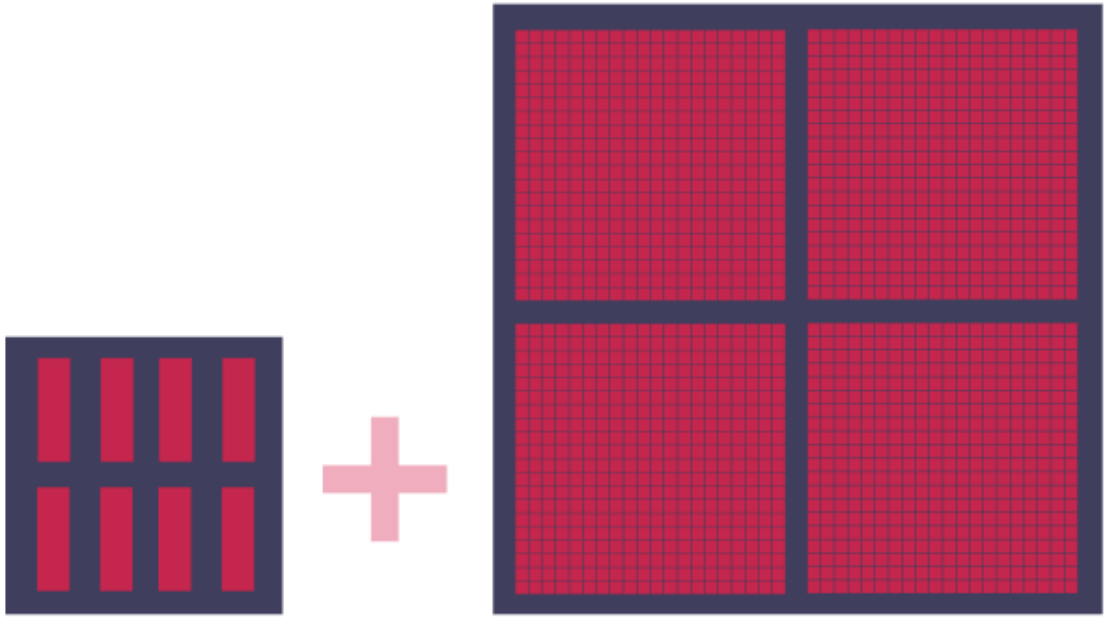
- A **co-processor** is an extra processor used to supplement the functions of the primary processor (the CPU)
  - It may be used to perform floating point arithmetic, graphics processing, digital signal processing and other functions
  - It generally carries out only a limited range of functions

GPU

- A **Graphics Processing Unit** (GPU) is a specialised electronic circuit which is very efficient at manipulating computer graphics and image processing
  - It consists of thousands of small efficient cores designed for parallel processing
  - It can process large blocks of visual data simultaneously
- In a PC, a GPU may be present on a graphics card

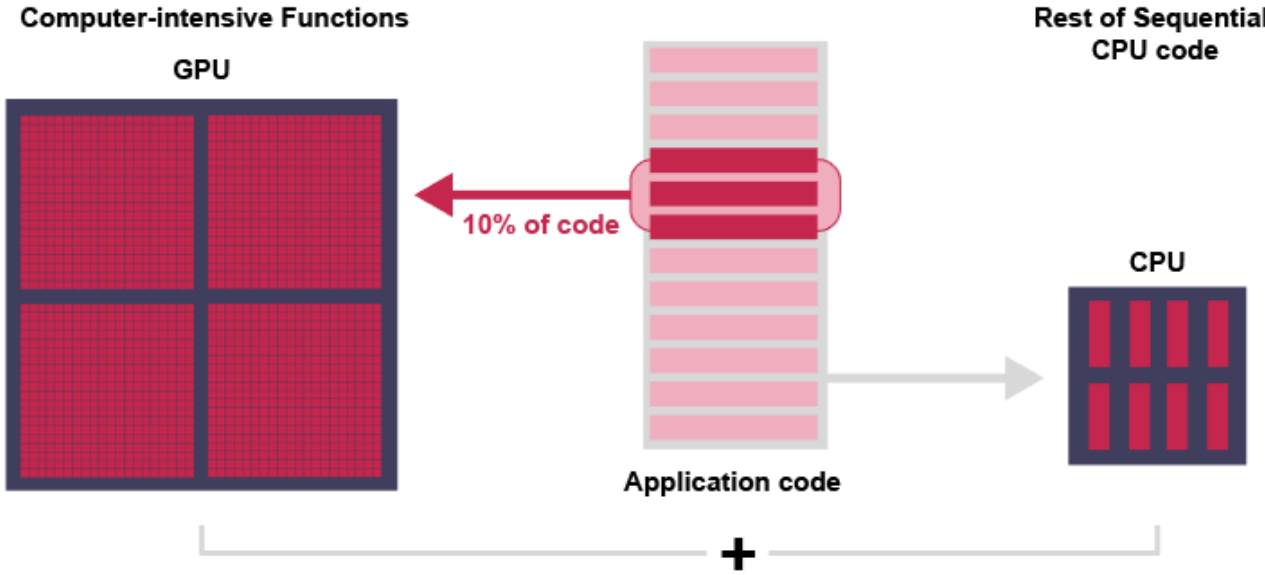
GPU

- A GPU has thousands of cores to process parallel tasks efficiently



Function of a GPU

- A GPU can act together with a CPU to accelerate scientific, engineering and other applications
  - They are used in numerous devices ranging from r bots



Worksheet slide

- Complete the questions in **Task 2** on **Worksheet 3**

Plenary

- There are two main processor architectures:
  - Von Neumann
  - Harvard
- The two main types of instruction set are CISC and RISC
- Multicore systems which enable parallel processing are common in computers from mobile devices to supercomputers
- GPUs are used for graphics processing and many other applications

Types of processor

Unit 1 Components of a computer and their uses

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